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Tidal Marsh Erosion by Geese, St. Lawrence Estuary, Québec
Érosion du schorre par les oies, estuaire du Saint-Laurent, Québec

Jean-Claude Dionne

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Résumé de l'article

Les oies causent des dommages au substrat des marais intertidaux (schorres) du Saint-Laurent. Leur activité printanière et automnale contribue ainsi à augmenter et à accélérer l'érosion par les agents naturels. La destruction précoce du couvert végétal à l'automne à la suite de l'arrivée massive des oies réduit son rôle protecteur contre l'érosion par les vagues et les courants de la vase fraîche déposée durant l'été. La surface vaseuse intensément picorée et piétinée par les oies est alors déstabilisée et sujette à une érosion subséquente plus importante. À la recherche des rhizomes, les oies creusent dans le substrat des milliers de petits trous, ce qui entraîne par la suite un démaigrissement de la surface du schorre inférieur d'une dizaine de centimètres d'épaisseur. Cette modification du profil a pour conséquence d'augmenter l'épaisseur de la nappe d'eau au-dessus de cette zone, de sorte qu'il y a augmentation de l'érosion par les vagues de la micro-falaise du schorre supérieur. De plus, les oies, en broutant le pourtour des mares, les agrandissent. De même, elles détruisent les radeaux du schorre et grugent le rebord du schorre inférieur et le font reculer. Même si les vagues, les courants et les glaces demeurent les principaux agents d'érosion du marais intertidal, on croit qu'une partie de l'érosion récente qui affecte le shorre de Montmagny est liée à l'action des oies.

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TIDAL MARSH EROSION BY GEESE, ST. LAWRENCE ESTUARY, QUÉBEC

Jean-Claude DIONNE, Département de géographie and Centre d'études nordiques, Université Laval, Sainte-Foy, Québec G1K 7P4.

ABSTRACT Damage by geese to tidal marsh substrates are evident in the St. Lawrence Estuary, Québec. Erosion is significantly increased by geese activity in autumn and spring. Rapid destruction of the vegetative cover in autumn leads to a reduction of the protective effects against waves and currents. Walking and probing in the soft sediment cover destabilize the mud surface and induce subsequent erosion. In search of rhizomes, geese dig many thousands of small holes in the substrate causing an average 10 cm lowering of the lower tidal marsh. As a consequence, erosion by waves of the upper marsh bluff is increased. In addition, geese contribute to the enlargment of shallow marsh depressions, to the destruction of peat blocks, and to the retreat of the lower marsh margins. Although wave, current and ice processes are prevailing, it is suggested that recent erosion of the tidal marsh in the Montmagny area is partly related to geese activity.

RÉSUMÉ *Érosion du schorre par les oies, estuaire du Saint-Laurent, Québec.* Les oies causent des dommages au substrat des marais intertidaux (schorres) du Saint-Laurent. Leur activité printanière et automnale contribue ainsi à augmenter et à accélérer l'érosion par les agents naturels. La destruction précoce du couvert végétal à l'automne à la suite de l'arrivée massive des oies réduit son rôle protecteur contre l'érosion par les vagues et les courants de la vase fraîche déposée durant l'été. La surface vaseuse intensément picorée et piétinée par les oies est alors déstabilisée et sujette à une érosion subséquente plus importante. À la recherche des rhizomes, les oies creusent dans le substrat des milliers de petits trous, ce qui entraîne par la suite un démaigrissement de la surface du schorre inférieur d'une dizaine de centimètres d'épaisseur. Cette modification du profil a pour conséquence d'augmenter l'épaisseur de la nappe d'eau au-dessus de cette zone, de sorte qu'il y a augmentation de l'érosion par les vagues de la micro-falaise du schorre supérieur. De plus, les oies, en broutant le pourtour des mares, les agrandissent. De même, elles détruisent les radeaux du schorre et grugent le rebord du schorre inférieur et le font reculer. Même si les vagues, les courants et les glaces demeurent les principaux agents d'érosion du marais intertidal, on croit qu'une partie de l'érosion récente qui affecte le shorre de Montmagny est liée à l'action des oies.

INTRODUCTION

Of the several tidal marshes occurring along the St. Lawrence Estuary (GAUTHIER *et al.*, 1980), those of the turbidity zone (D'ANGLEJAN and SMITH, 1973), particularly at Cap Tourmente, Île aux Grues and Montmagny are among the largest. They are visited twice a year by a large flock of geese (100 000 to 200 000 birds) migrating northward in spring (April-May) and southward in autumn (September-October). The flock is composed of Greater Snow Geese (*Ancer caerulescens atlanticus*) and has increased significantly during the last 15 years.

Preliminary studies have been made to estimate the impact of geese on the vegetative cover particularly *Scirpus americanus*, a prefered food of Greater Snow Geese (REED, 1977; DORAN, 1978; BÉDARD *et al.*, 1981). Additional and more specific studies are progressing at the Montmagny and Cap Tourmente tidal marshes. However, the preliminary results indicate that damage to the vegetative cover is less dramatic than expected. When moderately grazed by geese, the density of the plant cover is apparently not diminishing significantly. However, if the threshold of rhizome extraction is reached, a decline of *Scirpus americanus* could result (REED, 1984; GIROUX and BÉDARD, 1984). These results agree with those published elsewhere, although a decrease in productivity has been noted in some *Spartina alterniflora* marshes of eastern United States (WIDJESKOG, 1977; SMITH and ODUM, 1981; SMITH, 1983; PERRY *et al.*, 1984; YOUNG, 1984).

It is the purpose of this paper to report other damage caused by geese to tidal marshes along the St. Lawrence Estuary, particularly in the Montmagny area, based on repeated observations made during the last decade.

PREVIOUS OBSERVATIONS

Few authors have studied the damage caused by geese to the substrate of tidal marshes (DIONNE, 1984a). Some authors have noticed slight erosion induced locally by geese activity in the St. Lawrence tidal marshes (GAUTHIER, 1972; ALLARD, 1981; GAUTHIER and GOUDREAU, 1983; SÉRODES and DUBÉ, 1983; TROUDE *et al.*, 1983; SÉRODES and TROUDE, 1984). Elsewhere, some erosional effects of geese activity in tidal marshes have been observed.

At La Pérouse, Manitoba, on Hudson Bay, JEFFERIES *et al.* (1979, p. 1449) reported small ponds that "appear to have developed as a result of removal of the shallow turf and the effects of trampling of the geese. Continual trampling of geese damages the vegetation, reduces areas available for grazing, and produces depressions on the surface of the sediments which may become filled with water and ice, leading to further erosion". McATEE, (1910), McILHENNY, (1922), and LYNCH *et al.*, (1947) also reported similar impact of geese in marshes along the coast of the Gulf of Mexico. Where vegetation and sediments have been removed and disturbed by geese, formation of shallow ponds has resulted from subsequent storm action.

CHARACTERISTICS OF THE ENVIRONMENT

The Montmagny tidal marsh is located on the south shore of the middle St. Lawrence Estuary, about 65 km downstream from Québec City (Fig. 1). The marsh extends from Pointe Saint-Thomas in the west to Cap Saint-Ignace in the east, for an approximate distance of 15 km. Encompassed within a broad embayment facing the Montmagny Archipelago, the tidal marsh is composed of two units: a relatively narrow upper marsh 25 to 110 m wide, and a large lower marsh 120 to 650 m wide, where geese activity is concentrated (Fig. 2). The tidal marsh area occupies approximately 425 hectares. Within the area there are two small areas in which hunting is prohibited. These areas are more severely eroded in autumn during the hunting season than the adjacent tidal marsh areas.

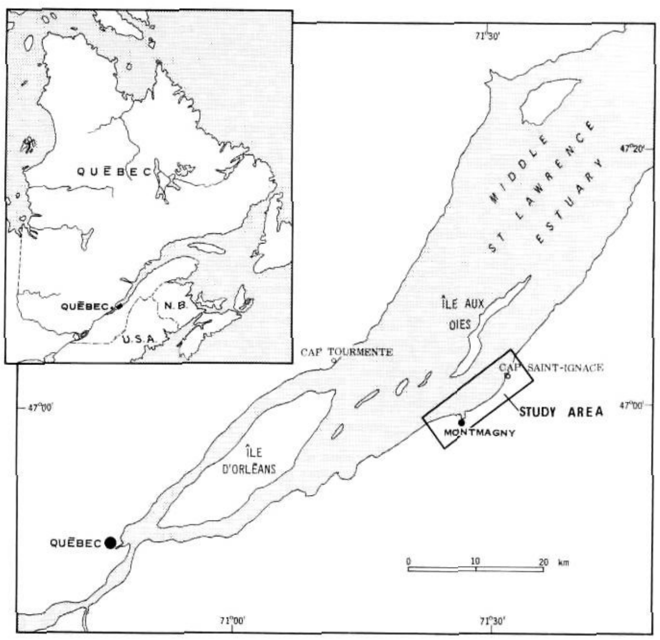


FIGURE 1. Location map, St. Lawrence Estuary, Québec.

Carte de localisation de l'estuaire du Saint-Laurent, Québec, et site étudié.

From the lower limit of the tidal marsh (which corresponds to mean sea level), to the lowest low tide level is an extensive and slightly sloping (0.25 to 0.40%) muddy tidal flat 600 to 1000 m in width. Mean semi-diurnal tide ranges from 4.5 to 5 m, while spring tides are 5.5 to 6 m high.

The dominating species of the vegetative cover of the lower tidal marsh are similar to the Cap Tourmente tidal marsh, where *Scirpus americanus* (60-70%) is mixed with *Zizania aquatica* and *Sagittaria latifolia* (DORAN, 1978).

Sedimentologically the lower marsh is composed of a layer 5 to 125 cm thick of recent stratified silt and fine sand, overlying post-glacial grey marine silty clay. However, in about one half of the area, the overlying recent alluvium is less than 30 cm thick. In many sites the underlying marine silty clay deposit commonly outcrops after periods of wave erosion in May. Substantial fresh mud deposition occurs during the summer (June to September). In the lower marsh, at the end of September, when the vegetative cover reaches a maximum, the covering soft muds are often 10 to 30 cm in thickness.

The Montmagny tidal flat and marsh are ice-covered from December to April and suffers severe ice erosion (DIONNE, 1968a, 1968b, 1972). Annually, several thousand tons of mud are exported seaward by ice from the tidal zone (DIONNE, 1984b). The tidal marsh also suffers severe erosion by waves and tidal currents in autumn (October-November) and particularly in spring (mid-April to mid-June). As a result, the annual sedimentary budget is very small and commonly nearly

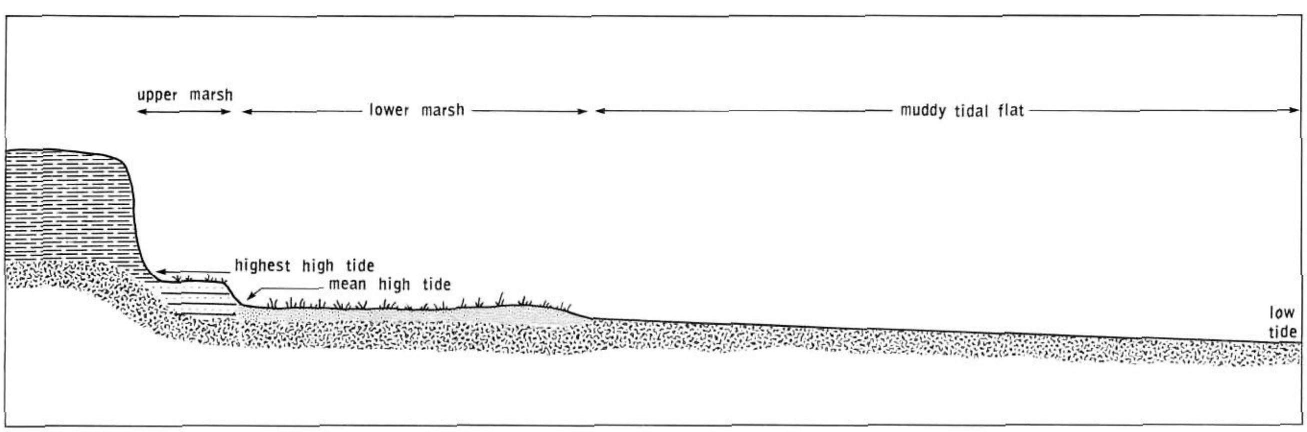


FIGURE 2. A schematic profile of the tidal zone showing the three classical units: a narrow upper marsh, a relatively wide lower marsh, and a large bare muddy tidal flat.

Profil transversal schématique du rivage de Montmagny montrant les trois unités habituelles: un schorre supérieur étroit, un schorre inférieur relativement large et une slikke vaseuse dénudée très étendue.

equals zero. Under such conditions, the local erosive effect of geese grazing and probing in the lower tidal marsh could have a negative effect on the evolution of the tidal marsh at Montmagny.

During the last decade, the upper tidal marsh at Montmagny has suffered erosion (LACOMBE, 1982). Measures made since 1981 indicate a mean retreat of 3 to 5 m in many places, while at three sites the upper marsh has been entirely eroded, allowing waves to reach the dead cliff (Mic Mac escarpment) and to rejuvenate it. In these sites the retreat by waves and ice erosion was 30 to 35 m.

THE EROSIVE EFFECT OF GEESE

The erosive effect of geese in tidal marshes is varied. Because of the great homogeneity of the vegetative cover and a better accessibility to roots, geese activity is mainly concentrated in the lower tidal marsh (Fig. 3).

ROLE ON THE VEGETATIVE COVER

It has been observed that geese feeding on roots of *Scirpus americanus* considerably disturb the surface of the tidal marsh. Because the vegetative cover is largely grazed by the geese in a few weeks, its protective effect is lost. In addition, walking and probing in the soft-sediments by geese contribute to destabilize the substrate (SÉRODES and TROUDE, 1984). As a result, waves and tidal currents can easily resuspend the disturbed sediments. The surface of the lower tidal marsh, which has substantially increased vertically during the summer, then returns to its former level after the two main periods of erosion (autumn and spring). This effect, particularly evident in the two non-hunting areas at Montmagny (Fig. 4), leads to a very slow vertical and lateral expansion of the lower tidal marsh. The first action of geese, which is to accelerate destruction of the vegetative cover and to disturb the muddy surface leading to subsequent erosion by waves and tidal currents, can be called indirect erosion.

HOLES MADE BY GEESE

Another effect of geese in the lower tidal marsh is the direct erosion of the substrate. Geese searching for roots of *Scirpus americanus* dig small holes in the muddy substrate (Fig. 5-6). These holes are commonly 6 to 12 cm in depth and 10 to 25 cm or more in diameter. Several thousands holes are made at each low tide in May and September-October. Locally the density of geese is such that large areas are pitted and covered by coalescent geese-made holes forming a characteristic surface pattern (Fig. 7-8). Although geese do not eat the mud and do not transport it elsewhere, the sediment extracted from the substrate is left at the surface, and it is subsequently resuspended easily by waves and carried away by tidal currents. As a result, the lower tidal marsh surface is lowered approximately 8-10 cm annually (Fig. 9). Because the lower tidal marsh surface is lowered repetitively, the depth of water over the substrate at high tide has been increased recently. Since waves and tidal currents have more energy, they can therefore cause more erosion at the upper tidal marsh bluff (Fig. 10).

ENLARGEMENT OF MARSH PANS AND RETREAT OF BLUFFS

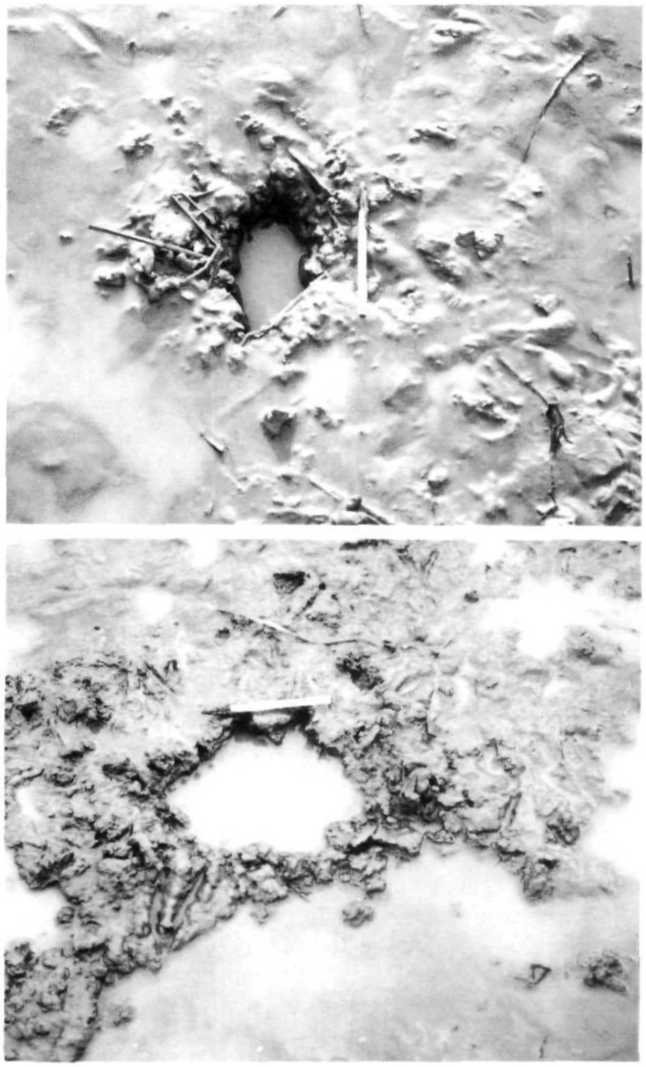
The St. Lawrence tidal marshes are characterized by the presence of numerous shallow depressions 10 to 30 cm in depth, mostly caused by ice action (DIONNE,1968a, 1968b, 1972). Geese in their search for rhizomes concentrate their activities along the rims of these shallow depressions thereby enlarging them. Measurements made at Montmagny and elsewhere along the St. Lawrence Estuary indicate that many

FIGURE 3. A general view of the lower tidal marsh at Saint-Vallier, south shore of the St. Lawrence Estuary, showing the Greater Snow Geese at work, autumn 1980.

Vue générale d'un schorre inférieur dans l'anse de Saint-Vallier, sur la rive sud du Saint-Laurent, montrant la grande oie blanche à l'œuvre, à l'automne 1980.

FIGURE 4. A residual surface in the lower tidal marsh after the departure of geese in a non-hunting area of the Montmagny tidal marsh (84.6.3).

Surface résiduelle du schorre inférieur après le départ des oies dans une aire de repos, à Montmagny.



FIGURES 5-6. Evidence of direct erosion by geese. Small holes, about 10 cm in depth and 15 to 25 cm in diameter, made by geese in search of rhizomes of *Scirpus americanus* in the lower tidal marsh at Montmagny (83.11.8).

Formes d'érosion directe par les oies. Trous, d'environ 10 cm de profondeur sur 15 à 25 cm de diamètre, faits par les oies à la recherche des rhizomes de scirpes américains dans le schorre inférieur, à Montmagny.

FIGURES 7-8. Pattern of small holes made by geese in the lower tidal marsh at Montmagny (83.5.16).

Aspects caractéristiques de la surface du schorre inférieur picorée par les oies à Montmagny.

depressions are enlarged by a few centimetres annually. In the lower tidal marsh enlargements of pans up to 10 cm have been measured in spring after the departure of the geese (Fig. 11).

The fringe of the lower tidal marsh is also affected by geese activity in spring, in the same way as for depressions (Fig. 12). Geese play an erosional role by tearing out the roots of plants and by grubbing in the compact mineral substrate. Retreats up to 30 cm have been measured locally in June. The disturbed clayed substrate is thus subsequently eroded more severely by waves. The direct erosional effect of geese in eroding the bluff of the upper marsh is less important although it does exist. Measures made at Montmagny indicate that the lower tidal marsh has retreated locally up to 5-6 m recently. Although waves are the main erosional agent, the activity of geese cannot be ignored.

DESTRUCTION OF PEAT CLUMPS

Because of ice action in cold region tidal marshes, numerous peat blocks are removed from the surface and scattered throughout the tidal zone (DIONNE, 1972, 1976). Depending on their position, peat blocks are progressively eroded by waves and currents. However, geese also contribute to their destruction. The access to roots being easier along the sides of peat blocks, geese concentrate their activity here and accelerate erosion. Field observations indicate that about one

FIGURE 9. Evidence of vertical erosion in a non-hunting area of the lower tidal marsh at Montmagny. The surface has been lowered about 10 cm (83.6.16).

Caillou glaciel sur piédestal témoignant d'un abaissement de la surface du schorre inférieur dans une aire de repos, à Montmagny.

FIGURE 11. Evidence of enlargement by geese of a shallow depression in the lower tidal marsh at Montmagny (83.5.16).

Rebord d'une mare superficielle dans le schorre inférieur grugé par les oies, à Montmagny.

FIGURE 10. Evidence of erosion by waves of the upper marsh bluff at Montmagny. The dark zone indicates a retreat of several metres during the last three years (84.6.15).

Exemple de l'érosion par les vagues du schorre supérieur, à Montmagny, au cours des trois dernières années. La partie foncée indique un recul de plusieurs mètres.

FIGURE 12. Type of erosion by geese occurring at the seaward limit of the lower tidal marsh and leading to its retreat, at Montmagny (83.5.16).

Érosion par les oies à la limite du schorre inférieur conduisant à son recul, à Montmagny.

quarter to one third of peat blocks measuring one square metre can be destroyed by geese activity in one year. In the area upstream of Québec City (Neuville, Saint-Antoine-de-Tilly, Sainte-Croix), peat blocks are commonly entirely destroyed by geese (Fig. 13) particularly in April, when the tidal marshes at Montmagny, Cap Tourmente and Île aux Grues, are still ice-covered.

DISCUSSION

Because of their great numbers, snow geese stopping during their migration twice a year in the tidal marshes of the upper middle St. Lawrence Estuary, and particularly at Montmagny, Île aux Grues and Cap Tourmente, and feeding in the same area for about 6 weeks, have a negative effect on the development of tidal marshes in the area. They disturbe the normal ecology of the lower marsh and produce drastic changes in the sedimentary cycle. In autumn, by destroying the vegetative cover over a short period, the protective effects of plants on the freshly deposited soft muds is greatly decreased. In addition, by their walking and probing in the sediment cover, geese contribute to the destabilisation of this fragile sedimentary environment and induce subsequent erosion in a period of time of increasing wave action due to meteorological conditions.

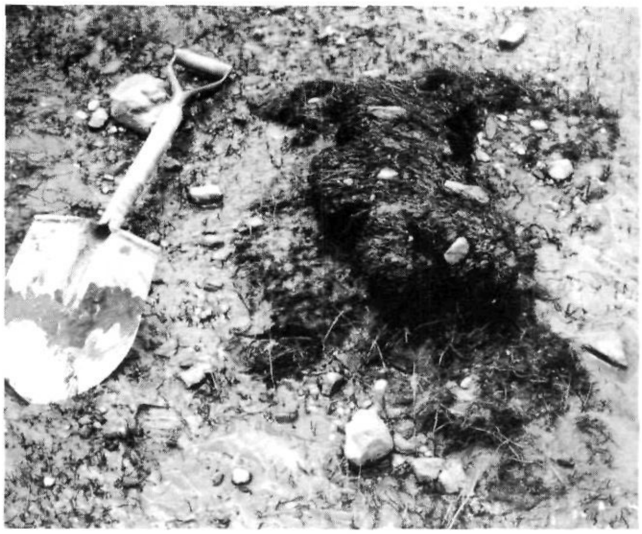


FIGURE 13. Remain of a peat block destroyed by geese, rocky shore platform at Saint-Antoine-de-Tilly (85.4.14).

Résidu d'un radeau de schorre grugé par les oies sur la plate-forme rocheuse à Saint-Antoine-de-Tilly.

Geese also contribute to the retreat of the margins of the lower marsh and the bluff of the upper marsh. They aid in the enlargment of shallow ice-made depressions and to the destruction of peat blocks scattered throughout the tidal zone. Another important effect of geese is the numerous small holes made in search of rhizomes of *Scirpus americanus*. This leads to a significant lowering of the surface of the lower tidal marsh. The change in profile of the substrate in spring leads to an increased erosion of the upper marsh. This is quite evident in the two non-hunting areas at Montmagny which are more severely eroded than the adjacent areas.

The recent erosion of the upper marsh observed at Montmagny for about half of its entire length implies significant changes in the previous environmental conditions. Although it is difficult to determine precisely the factors causing this erosion, it is likely that the activity of geese disturbing the substrate and anthropic erosion play a role (DIONNE, 1984c, 1985). It is evident, however, that most of the erosion is caused by waves, currents and shore ice. If the increasing action of waves in eroding the upper marsh is not related to a lowering of the lower tidal marsh surface partially caused by geese action, then sea level is rising or land is subsiding.

CONCLUSION

It is suggested that recent erosion of the tidal marshes along the St. Lawrence Estuary and particularly at Montmagny is partly related to geese activity during the last decade. Besides the role of geese in altering the vegetative cover there is a need for additional investigations of the erosional effects of geese in the development of tidal marshes. An effort should be made to determine how the damage made by geese could be circumvented rapidly. Geese activity is obviously significant to marsh environment in a physical as well as a biotic sense. An increase in hunting could be a valuable solution to counter the negative effects of the Greater Snow Geese in the St. Lawrence Estuary tidal marshes.

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